

layer, for example, and an electrode (not shown in the figure) paired with a transparent electrode 716 shown in the figure formed on a transparent substrate 714 is formed to form an element disposing functional thin film 712 therebetween. It will also be obvious that the electrodes can be formed using the pattern forming method of the present invention.

The film thickness of the functional thin film 712 can be determined according to the intended application of the microstructure, but is preferably 0.02 to 4 μm . Products manufactured by applying the film formation method of the present invention are high quality, and superior to the conventional method with respect to production cost and simplification of the production process.

APPLICATIONS IN INDUSTRY

As described above, the present invention can form a pattern by simply filling a liquid pattern material to pattern forming trenches and solidifying the liquid pattern material. The present invention therefore does not need to use high cost vacuum equipment. As a result, the present invention does not require a load lock chamber for transporting work into a vacuum, plural dry pumps and turbo pumps for making the process chamber a vacuum, the increased footprint required to provide plural chambers in order to improve throughput, the attendant increase in clean room size, and the increase in basic equipment used to maintain the same, and therefore helps simplify the equipment, reduce the amount of energy used in pattern forming, and reduce the pattern forming cost. Furthermore, because the present invention does not use CVD, for example, it is not necessary to use PFC gas having a high global warming coefficient in order to clean the equipment, thus reducing cost and significantly reducing the effect on the global environment.

WHAT IS CLAIMED IS:

1. A pattern forming method characterized by forming a mask having pattern forming openings on a workpiece surface, and then supplying and solidifying a liquid pattern material in the pattern forming openings of the mask.

2. A pattern forming method comprising:
 - a mask forming process for forming a mask having pattern forming openings on a workpiece surface;
 - a pattern material supplying process for supplying the liquid pattern material to the mask openings while also drying the liquid pattern material;
 - a process for removing the mask from the workpiece; and
 - an annealing process for annealing dried solute of the liquid pattern material.

3. A pattern forming method comprising:
- a mask forming process for forming a mask having pattern forming openings on a workpiece surface;
 - a pattern material supplying process for supplying a liquid pattern material to the mask openings;
 - a drying process for evaporating solvent in the liquid pattern material;
 - a mask removal process for removing the mask from the workpiece; and
 - an annealing process for annealing dried solute in the liquid pattern material.
4. A pattern forming method comprising:
- a mask forming process for forming a mask having pattern forming openings on a workpiece surface;
 - a pattern material supplying process for supplying a liquid pattern material to the mask openings;
 - a solidifying process for solidifying the liquid pattern material supplied into the openings; and
 - a mask removal process for removing the mask from the workpiece after sequentially performing plural times the pattern material supply process and solidifying process.
5. A pattern forming method comprising:
- a mask forming process for forming a mask having pattern forming openings on a workpiece surface;
 - a pattern material supplying process for supplying a liquid pattern material to the mask openings;
 - an adherent liquid removal process for removing liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the openings;
 - a drying process for drying by evaporating solvent in the liquid pattern material in the openings;
 - an annealing process for annealing the dried solute after sequentially performing plural times the pattern material supply process, adherent liquid removal process, and drying process; and
 - a mask removal process for removing the mask from the workpiece.
6. A pattern forming method comprising:
- a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying a liquid pattern material to the mask openings;

a drying process for drying by evaporating solvent in the liquid pattern material in the openings; and

an annealing process for annealing the dried solute after sequentially performing plural times the pattern material supply process and drying process.

7. A pattern forming method comprising:

a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying a liquid pattern material to the mask openings;

a solidifying process for solidifying the liquid pattern material supplied into the trenches;

a solid material removal process for removing solids of the liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the mask openings; and

a mask removal process for removing the mask from the workpiece after sequentially performing plural times the pattern material supply process, solidifying process, and solid material removal process.

8. A pattern forming method comprising:

a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying a liquid pattern material to the mask openings;

a drying process for drying by evaporating solvent in the liquid pattern material in the openings;

a solid material removal process for removing dried solids of the liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the mask openings;

an annealing process for annealing the dried solute after sequentially performing plural times the pattern material supply process, drying process, solid material removal process; and

a mask removal process for removing the mask from the workpiece.

9. A pattern forming method comprising:

a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying a liquid pattern material to the mask openings;

a drying process for drying by evaporating solvent in the liquid pattern material in the openings;

a solid material removal process for removing dried solids of the liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the mask openings;

an annealing process for annealing the dried solute; and

a mask removal process for removing the mask from the workpiece after sequentially performing plural times the pattern material supply process, drying process, solid material removal process, and annealing process.

10. A pattern forming method as described in any of claims 1 to 9, wherein the mask has hydrophobic on at least the surface thereof.

11. A pattern forming method as described in any of claims 1 to 9, wherein the mask is hydrophobic.

12. A pattern forming method as described in claim 1, claim 4, or claim 7, wherein the liquid pattern material is solidified by applying heat.

13. A pattern forming method as described in claim 12, wherein heating and solidifying the liquid pattern material comprises a drying process for evaporating solvent in the liquid pattern material, and an annealing process for annealing the dried solute.

14. A pattern forming method as described in claim 1, wherein the mask is removed from the workpiece after solidifying the liquid pattern material.

15. A pattern forming method as described in any of claims 1 to 4 or claim 7, wherein: the liquid pattern material is solidified after removing liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the openings.

16. A pattern forming method as described in claim 6, wherein the annealing process is performed after removing the mask from the workpiece.

17. A pattern forming method as described in claim 6, wherein the mask is removed from the workpiece after the annealing process.

18. A pattern forming method as described in claim 2, claim 3, claim 5, claim 6, or claim 8, wherein the process for removing the mask and the annealing process are performed simultaneously.

19. A pattern forming method comprising:

a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying the liquid pattern material to the mask openings while also drying the liquid pattern material;

an annealing process for annealing dried solute of the liquid pattern material; and

a process for removing the mask from the workpiece.

20. A pattern forming method comprising:

a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying a liquid pattern material to the mask openings;

a drying process for evaporating solvent in the liquid pattern material;

an annealing process for annealing dried solute in the liquid pattern material; and

a mask removal process for removing the mask from the workpiece.

21. A pattern forming method comprising:

a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying a liquid pattern material to the mask openings;

an adherent liquid removal process for removing liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the openings;

a drying process for drying by evaporating solvent in the liquid pattern material in the openings;

a mask removal process for removing the mask from the workpiece after sequentially performing plural times the pattern material supply process, adherent liquid removal process, and drying process; and

an annealing process for annealing the dried solute.

22. A pattern forming method comprising:

a mask forming process for forming a mask having pattern forming openings on a workpiece surface;

a pattern material supplying process for supplying a liquid pattern material to the mask openings;

a drying process for drying by evaporating solvent in the liquid pattern material in the openings;

a solid material removal process for removing dried solids of the liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the mask openings;

a mask removal process for removing the mask from the workpiece after sequentially performing plural times the pattern material supply process, drying process, and solid material removal process; and

an annealing process for annealing the dried solute.

23. A pattern forming method characterized by supplying and solidifying a liquid pattern material in a specific pattern forming trench disposed in a workpiece.

24. A pattern forming method characterized by performing plural times a process for supplying and solidifying a liquid pattern material in a specific pattern forming trench disposed in a workpiece.

25. A pattern forming method comprising:

a pattern material supply process for supplying a liquid pattern material to a specific pattern forming trench disposed in a workpiece;

an adherent liquid removal process for removing liquid pattern material that adhered to the mask surface when the liquid pattern material was supplied to the trench;

a drying process for drying by evaporating solvent in the liquid pattern material in the trench; and

an annealing process for annealing solute contained in the dried liquid pattern material after sequentially performing plural times the pattern material supply process, adherent liquid removal process, and drying process.

26. A pattern forming method characterized by sequentially performing plural times:

a pattern material supply process for supplying a liquid pattern material to a specific pattern forming trench disposed in a workpiece;

a solidifying process for heating and solidifying the liquid pattern material supplied to the trench; and

an adherent solid removal process for removing solids of the liquid pattern material that adhered to the workpiece surface when the liquid pattern material was supplied to the trench.

27. A pattern forming method comprising:

a pattern material supply process for supplying a liquid pattern material to a specific pattern forming trench disposed in a workpiece;

a drying process for evaporating solvent in the liquid pattern material supplied to the trench; and

an annealing process for annealing solute contained in the dried liquid pattern material after sequentially performing plural times the pattern material supply process and drying process.

28. A pattern forming method comprising:

a pattern material supply process for supplying a liquid pattern material to a specific pattern forming trench disposed in a workpiece;

a drying process for evaporating solvent in the liquid pattern material supplied to the trench;

an adherent solid removal process for removing dried solids of the liquid pattern material that adhered to the workpiece surface when the liquid pattern material was supplied to the trench; and

an annealing process for annealing solute contained in the dried liquid pattern material after sequentially performing plural times the pattern material supply process, drying process, and adherent solid removal process.

29. A pattern forming method characterized by performing once or plural times:

a pattern material supply process for supplying a liquid pattern material to a specific pattern forming trench disposed in a workpiece;

a drying process for evaporating solvent in the liquid pattern material supplied to the trench;

an adherent solid removal process for removing dried solids of the liquid pattern material that adhered to the workpiece surface when the liquid pattern material was supplied to the trench; and

an annealing process for annealing solute contained in the dried liquid pattern material.

30. A pattern forming method as described in any of claims 23 to 29, wherein:
the liquid pattern material is supplied to the trench after hydrophobic processing the workpiece surface.
31. A pattern forming method as described in any of claims 23 to 29, wherein:
the liquid pattern material is supplied to the trench after hydrophobic processing the workpiece surface, and hydrophilic processing the trench bottom.
32. A pattern forming method as described in claim 23, claim 24, or claim 26, wherein:
the liquid pattern material is solidified by heating the liquid pattern material.
33. A pattern forming method as described in claim 32, wherein:
heating and solidifying the liquid pattern material comprises a drying process for evaporating solvent in the liquid pattern material, and an annealing process for annealing the dried solute.
34. A pattern forming method as described in claim 23, characterized by solidifying the liquid pattern material and then removing solids of the liquid pattern material that adhered to the workpiece surface when the liquid pattern material was supplied to the trench.
35. A pattern forming method as described in claim 23, wherein solidifying the liquid pattern material is performed after removing liquid pattern material that adhered to the workpiece surface when the liquid pattern material was supplied to the trench.
36. A pattern forming method as described in claim 27, wherein the annealing process is performed after removing dried solids of liquid pattern material that adhered to the workpiece surface when the liquid pattern material was supplied to the trench.
37. A pattern forming method comprising:
a process for disposing an organic film on a workpiece surface;
a process for forming a trench of a specific pattern in the organic film;
a process for filling the trench with an inorganic material;
a process for removing inorganic material except from inside the trench; and
a process for removing the organic film and leaving a pattern of the inorganic material.

38. A pattern forming method as described in claim 37, wherein the process for filling the trench with an inorganic material is accomplished by applying a solution containing the inorganic material.
39. A pattern forming method as described in claim 38, wherein the inorganic material is a liquid or a liquid-gas mixture.
40. A pattern forming method as described in claim 38 or claim 39, wherein:
the inorganic material is applied by spin coating.
41. A pattern forming method as described in claim 38 or claim 39, wherein:
the inorganic material is applied spraying.
42. A pattern forming method as described in claim 37, wherein:
the process for removing inorganic material except inside the trench is accomplished by applying an etching solution.
43. A pattern forming method as described in claim 42, wherein:
the etching solution is a liquid or a liquid-gas mixture.
44. A pattern forming method as described in claim 42 or claim 43, wherein:
the etching solution is applied by spin etching.
45. A pattern forming method as described in claim 42 or claim 43, wherein:
the etching solution is applied by spraying.
46. A pattern forming method as described in claim 37, wherein:
the process for removing inorganic material except inside the trench is accomplished by CMP.
47. A pattern forming method as described in claim 37, wherein:
the organic film is removed with atmospheric pressure plasma.
48. A pattern forming apparatus comprising:
a mask forming unit for forming a mask by disposing pattern forming openings in a mask material coated to and solidified on a workpiece surface;

a hydrophobic processing unit for hydrophobic processing the solidified mask material or mask;

a pattern material supply unit for supplying a liquid pattern material to the pattern forming openings of the mask; and

a solidification unit for solidifying the liquid pattern material in the pattern forming openings.

49. A pattern forming apparatus comprising:

a mask forming unit for forming a mask by disposing pattern forming openings in a mask material coated to and solidified on a workpiece surface;

a hydrophobic processing unit for hydrophobic processing the solidified mask material or mask;

a pattern material supply unit for supplying a liquid pattern material to the pattern forming openings of the mask;

a solidification unit for solidifying the liquid pattern material in the pattern forming openings; and

a mask removal unit for removing the mask after solidifying the liquid pattern material.

50. A pattern forming apparatus as described in claim 48 or claim 49, wherein:

the hydrophobic processing unit comprises a plasma generating means for producing a fluoride gas plasma at atmospheric pressure or near atmospheric pressure, and supplying the plasma to the solidified mask material or mask.

51. A pattern forming apparatus as described in claim 48 or claim 49, wherein:

the hydrophobic processing unit comprises a polymerization means for producing a fluorocompound plasma, and polymerizing a fluororesin film on the surface of the solidified mask material or mask.

52. A pattern forming apparatus as described in claim 50 or claim 51, wherein:

the hydrophobic processing unit comprises a hydrophilic processing means for making inside the pattern forming openings of the hydrophobic processed mask hydrophilic.

53. A pattern forming apparatus comprising:

a mask forming unit for forming a mask comprising a hydrophobic film having pattern forming openings on the surface of a workpiece;

a pattern material supply unit for supplying a liquid pattern material to the pattern forming openings of the mask;

a solidification unit for solidifying the liquid pattern material in the pattern forming openings; and

a mask removal unit for removing the mask after solidifying the liquid pattern material.

54. A pattern forming apparatus as described in claim 50, wherein:

the mask forming unit comprises a polymerization means for producing a fluorocompound plasma, and polymerizing a fluororesin film on the surface of the workpiece through a transfer mask.

55. A pattern forming apparatus as described in any of claims 48 to 54, wherein:

the pattern material supply unit comprises an adherent liquid removal means for removing liquid pattern material adhering to the mask surface.

56. A pattern forming apparatus as described in any of claims 48 to 54, wherein:

the pattern material supply unit comprises an atomization means for atomizing and misting the liquid pattern material on the mask.

57. A pattern forming apparatus as described in claim 56, wherein:

the pattern material supply unit comprises a rotating means for rotating the workpiece.

58. A pattern forming apparatus as described in claim 56 or claim 57, wherein:

the pattern material supply unit comprises a voltage applying means for applying a voltage to the workpiece so that static attraction works to attract the atomized liquid pattern material to the workpiece.

59. A pattern forming apparatus as described in any of claims 48 to 58, wherein:

the solidification unit comprises a heating means disposed in the pattern material supply unit for heating and solidifying the liquid pattern material.

60. A semiconductor device characterized by being manufactured using a pattern forming method as described in any of claims 1 to 47.

61. An electrical circuit characterized by being manufactured using a pattern forming method as described in any of claims 1 to 47.

62. A display module characterized by being manufactured using a pattern forming method as described in any of claims 1 to 47.

63. A color filter characterized by being manufactured using a pattern forming method as described in any of claims 1 to 47.

64. A light-emitting element characterized by being manufactured using a pattern forming method as described in any of claims 1 to 36.